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Objectives for Evaluation of Alternative Approaches for Strontium-90 Cleanup at 100-N

DOE Richland Operations is evaluating remedial technologies and addressing issues to develop a final approach for remediation of strontium-90 at the 100-NR-2 Operable Unit. The current baseline, based on a 1999 Record of Decision (ROD) addresses both soil and groundwater contamination at 100-N. Soil remediation is progressing by removing soils in the discharge trenches to 15 feet below grade and disposing the soil in the Environmental Restoration Disposal Facility (ERDF). Groundwater remediation is being accomplished through operation of an interim pump and treat system to reduce the flux of strontium-90 to the Columbia River.

An Innovative Technology and Remediation Demonstration (ITRD) review process for the 100-N Area identified technologies that could be used to remediate strontium-90 contaminated groundwater in the 100-NR-2 Operable Unit. The review evaluated monitored natural attenuation (MNA), a clinoptilolite barrier, phytoremediation, sheet pile/cryogenic barrier, and soil flushing. An ITRD report identified monitored natural attenuation, phytoremediation, and reactive barriers for further study. Strontium-90 sequestration by apatite has the potential for lowering the dissolved concentrations in groundwater and preventing further migration into the Columbia River. The proposed approach for apatite sequestration is conceptually different than the one considered and rejected by the ITRD project, and is anticipated to overcome the technical flaws previously identified.

DOE Richland Operations is funding activities to develop information needed to reach the final record of decision for 100-NR-2: evaluation of apatite sequestration and phytoremediation as remediation technologies for the near-shore environment, an ecological assessment to evaluate risks of contamination, and laboratory studies to evaluate the uptake of strontium-90 by aquatic plants and fish to provide data for site-wide and site-specific risk assessments. These activities will fit into the CERCLA feasibility process by providing data to determine whether or not either of the technologies will reduce the flux of contaminated groundwater to the Columbia River and to estimate the costs and benefits of full-scale implementation. A test plan will be developed for evaluating both of the technologies. The plan will refine, if necessary, the applicable or relevant and appropriate requirements (ARAR) and remedial action objectives (RAO) defined in the Interim Remedial Action Record of Decision for 100-NR-2 and evaluate these technologies against CERCLA criteria. The objectives of each of these activities are as follows.

Evaluation of Apatite Sequestration

- Determine the viability of the technology to reduce the flux of strontium-90 reaching the Columbia River from upwelling groundwater by measuring the kinetics of apatite precipitation and its effectiveness at sequestering strontium-90
- Determine the feasibility of liquid apatite injection through laboratory experiments and determine optimal parameters for reagent injection to produce a viable strontium-90 barrier and develop parameters needed for long-term predictions of barrier performance and longevity of the reactive zone
- Scale up a technology that has been successfully demonstrated in the laboratory to the field

Evaluation of Phytoremediation

- Determine the viability of the technology to remove strontium-90 from the soil proximal to the Columbia River and reduce the flux of strontium-90 reaching the river from upwelling groundwater
- Determine the kinetics of strontium accumulation in plants, the effect of different strontium to calcium ratios on plant uptake of strontium, strontium-90 to stable strontium uptake, and where strontium-90 is deposited in plants
- Determine the impacts of food chain transfer leading to insects, birds, mammals, fish, and other animals
- Scale up the technology to form an effective barrier in the field and determine the feasibility of engineering controls for prevention of herbivore, bird, insect, and human intrusion as well as to control loss of plant litter
- Determine whether the plants utilized for the phytoremediation barrier can survive on the shoreline at 100-N and how deep the roots will go.

Ecological Assessment of 100-N Area

- Establish a baseline of strontium-90 in the near-shore aquatic and riparian environment and key biological receptors to perform an ecological risk assessment and implement a monitoring program for 100-N Area
- Identify contamination and determine if it presents a risk to humans and plant and animal life.

Biological Uptake of Strontium-90 by Aquatic Plants and Species

- Measure the biological response and uptake of strontium-90 by an aquatic plant (periphyton) and rainbow trout to support site-wide and site-specific ecological risk assessments
- Determine the fate and transport of strontium-90 in the river environment and the primary response mechanisms for exposed aquatic and riparian organisms
- Provide data and models for site-wide and site-specific ecological risk assessments; as is the case for strontium-90, site-specific data for many radionuclides do not exist.

Summary of Approach

This project will fill in gaps in scientific knowledge and evaluate technologies that will allow Fluor and DOE Richland to manage technical risks in implementing an alternative approach to reducing the flux of strontium-90 upwelling in the Columbia River within the 100-NR-2 Operable Unit. The project will conduct laboratory and field-scale investigations, along with modeling, to develop data and evaluate alternative remediation approaches.

Specific activities to address apatite sequestration include:

- Laboratory experiments to measure parameters for geochemical modeling to estimate the potential release of strontium-90 to the river during the injection phase
- Laboratory experiments to determine the rate of strontium-90 incorporation into the apatite structure
- Intermediate-scale laboratory experiments to quantify geochemical processes in a flowing system around a well, demonstrate that the liquid apatite solution can be injected and apatite evenly precipitated in porous media, and determine the impacts of microbial populations

- If the technology is determined to be technically feasible, single-well field-scale demonstrations of the barrier technology involving injection of the apatite solution in single wells at an uncontaminated site and at 100-NR-2 and performing characterization and monitoring to determine barrier performance with time.

Specific activities to address phytoremediation include:

- Greenhouse studies to determine the influence of soil strontium to calcium ratios on the viability of phytoremediation of strontium-90 by coyote willows, resolve the kinetics of strontium accumulation in coyote willow, and determine the impacts of nutrients (fertilizers) on strontium accumulation and plant partitioning
- Greenhouse and growth chamber studies to determine food chain transfer between the plants and insects
- Field study of strontium uptake in existing populations of coyote willow shrubs growing at or near the 100-N Area
- Develop engineering controls for control of plant litter and intrusion by herbivores, birds, insects, and humans
- If the technology is determined to be technically feasible, a field treatability study involving establishing plants along the Columbia River at 100-NR-2, construction of a structure to control plant litter and intrusion, and monitoring for a 3-year period.

Specific activities for the ecological assessment are similar to the assessment described in the 100 B/C Area Risk Assessment and include:

- Sampling water from riverbank springs and other media along the 100-NR-2 shoreline at low river stage
- Collecting and analyzing samples of water, biota, and sediments as well as measuring external radiation levels.

The biological uptake studies of strontium-90 are underway as part of the Groundwater Protection Program Science and Technology Project and involve laboratory experiments with an aquatic plant (periphyton). Laboratory experiments for uptake of strontium-90 by rainbow trout will also be completed in FY 2003.